Machine Vision
1998-99

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Advanced MSc in:
Vision, Imaging & Virtual Environments,
Research Masters in:
Computer Vision, Image Processing, Graphics and Simulation

Part I: Fundamentals (15 hours)

Week	Begins	#	Lecturer	Topics
1	27/9			**Introductory Week: Maths and Programming Revision**
2	4/10			**PPSRP Week**
3	11/10	1	BFB	**Introduction**: motivation and challenges: timeliness, sensor technology, computer technology, algorithms.
		2	BFB	**Simple image models**: digital imaging, grey-level quantisation, optimal quantisation.
		3	BFB	**Image formation**: photometry, projection model, projective, orthographic and affine imaging, weak perspective and paraperspective.
4	18/10	4	BFB	**Basic operations**: low-level image processing; point operations, contrast manipulation, contrast stretching, image addition and image subtraction.
		5	BFB	**Geometric and spatial transformations**: bilinear interpolation, linear geometric transformations, separable geometric transformations.
		6	BFB	**Image warping**, forward and backward mappings, control points, least squares solutions, over- and under-determined warps.
5	25/10	7	BFB	**Global operations**: histogram equalisation, thresholding. Image segmentation, region growing, split and merge algorithms.
		8	BFB	**Morphological Operations**: binary image processing, set operations, structuring element, hit and miss transform, erosion, dilation.
		9	BFB	**Morphological processing**: opening and closing, thinning and thickening, examples; non-linear operations, introduction to grey-level morphology, examples.
6	1/11	10	BFB	**Morphological descriptions**: connected component labelling, consistency, 4 and 8 way connectivity, skeltonisation, medial axis and related transforms.
		11	BFB	**Description of binary shapes**: run-length encoding, coding a boundary, region properties, discretisation, position, orientation and noise effects.
		12	BFB	**Spatial moments**: second order moments, principal axes, eigenvalues and eigenvectors, invariant moments, scaling, higher order moments.
7	8/11	13	BFB	**Image measurements and classification**: pattern recognition, template matching, decision functions.
		14	BFB	**Local image structure**: matching metrics, template matching and cross-correlation.
		15	BFB	**Performance characterisation**: receiver operating characteristic (ROC) curve, Bayes loss and value, relationship to ROC.

Part II: Advanced Topics and Applications (15 hours)

Week	Begins	#	Lecturer	Topics
8	15/11	16	BFB	**Low-level operations**: digital filtering and convolutions, smoothing, low-level feature extraction, introduction to edge detection.
		17	BFB	**Edge detection**: Marr-Hildreth, Canny, smoothing, non-maximal suppression, hysteresis (linking), introduction to scale space.
		18	BFB	**Low-level feature extraction**: Harris/Noble corner detection, interest operators, Forstner, sub-pixel acuity.
9	22/11	19	SR/DPC	**Stereo image geometry**: Collinearity, resection, intersection, epipolar constraints, geometric limitations of practical images.
		20	SR/DPC	**Images to surfaces**: Stereo point and area correspondence solutions, extension to multiple image networks incorporating over-determination.
		21	SR/DPC	**Images to models**: Example applications utilising stereo and multi-photo geometries, in association with techniques such as Delaunay triangulation.
10	29/11	22	BFB	**Geometric invariance**: Euclidean, affine and projective invariants, cross-ratios, comparison with conventional shape descriptors.
		23	BFB	**Homographies**: mapping from a plane to a plane, application to plane figures and to camera calibration, uncalibrated stereo mappings.
		24	BFB	**Point distribution models**: principal components analysis, comparison with template models, appearance models.
11	6/12	25	BFB	**Active shape models**: image search, applications to inspection and face recognition.
		26	BFB	**Eigenspace methods**: (time permitting) effect of changing viewpoint, application to object recognition.
		27	BFB	**Kalman filtering**: principles and formulation.
12	14/12	28	BFB	**Kalman filtering**: application to point (corner) tracking, motion estimation and data fusion, time to contact (focus of expansion/epipole).
		29	BFB	**Optical flow**: motion constraint equations, motion estimation and the image motion field.
		30	BFB	**Tracking**: tracking of image features (corners), cross-correlation, active vision, applications of tracking.

Note:
1. VIVE MSc: All of parts I & II are examinable.
2. CVIPGS MRes: Examination questions will not be set specifically on the content of part I above, but knowledge of these topics will be required if they arise within the context of a question set on the advanced topics and applications from part II.
3. Coursework I is based on topics in part I, but contributes towards the course credit for both the VIVE MSc and the CVIPGS MRes.

Courseworks and Practicals (~ 20 hours)

#	Week Set	Week due	Responsible	Topic
1	5 18/10	7 3/11	BFB	**Basic operations:** use of computer facilities, libraries and environments, application to image capture, grey-level transformations and gamma correction, geometric transformations, interpolation (nearest neighbour and bilinear), illustration by image warping according to linear (affine) and non-linear maps, image subtraction for object detection, morphological operations, critique.
2	8 8/11	11 6/12	JPM/DB	**Edge detection**: Gaussian (separable) convolution, non-maximal suppression, hysteresis (Canny), application to images of simple objects, evaluation using ROC, critique.
3	10 22/11	14 17/1	BFB	**Lines:** use of Canny edge detection (executable supplied), histogramming and PCA to find lines in images of 2D geometric object, calculation of affine and perspective invariants, comparison with ground truth, critique.

Note:

1. All courseworks are assessed and contribute 25% towards both the VIVE MSc and the CVIPGS MRes.

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